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SUBMISSION OF PRIOR ART UNDER 37 C.F.R. §501

APPLICANTS: Schreck et al. GROUP ART UNIT: 2859

SERIAL NO.: 10/691,405 EXAMINER: Louis M. Arana

FILED: October 22, 2003 CONFIRMATION NO.: 6845

PATENT NO.: 6,952,097 **ISSUE DATE: October 4, 2005**

TITLE: "METHOD FOR SLICE POSITION PLANNING OF TOMOGRAPHIC MEASUREMENTS, USING STATISTICAL IMAGES"

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S I R:

In accordance with the provisions of 37 C.F.R. §501, the owner of the above-referenced patent requests that the following prior art be placed in the file for the above-referenced patent maintained by the United States Patent and Trademark Office.

United States Patent Application Publication No. 2003/0139944

United States Patent Application Publication No. 2002/0198447

PCT Application WO 2004/080309

EXPLANATION OF RELEVANCE

The above references were among the references cited in a Search Report rendered by the Netherlands Patent Office contemporaneously with the allowance of the above-referenced patent. A copy of the Netherlands Search Report is submitted herewith. United States Patent No. 6,195,409, which is also listed on the Netherlands Search Report, has already been made of record during the prosecution of the above-referenced patent.

The patent owner submits that had these references been considered by the United States Examiner, none of the references would have required any alteration of the allowed claim language.

Copies of each of the above references are submitted herewith.

Submitted by,

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CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450 on January 9, 2006.

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CH1\ 4437654.1

STANDARD SEARCH REPORT

Patent Application
No. 1027333

P217809NL

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citations of document with indication, where appropiate, of the relevant passages or drawings	Relevant to claim No.	International classification
D,X	US 6 195 409 B1 (CHANG LINDA ET AL) 27 februari 2001 (2001-02-27) * kolom 4, regel 25 - kolom 6, regel 27 *	1-26	A61B5/055 A61B6/03 G01R33/48
X	WO 2004/080309 A (PHILIPS INTELLECTUAL PROPERTY & STANDARDS GMBH; KONINKLIJKE PHILIPS EL) 23 september 2004 (2004-09-23) * bladzijde 2, regel 10 - bladzijde 7, regel 16; conclusies *	1-3,5, 8-13, 15-25	
A	US 2002/198447 A1 (VAN MUISWINKEL ARIANNE MARGARETHE CORINNE ET AL) 26 december 2002 (2002-12-26) * alineas ‘0029! - ‘0032! *	1,8,15	
A	US 2003/139944 A1 (CARLSEN INGWER ET AL) 24 juli 2003 (2003-07-24) * het gehele document *	1,8,15	**Technical Fields Search** A61B G01R

This report relates to all claims

Date of completion of the search: 9 June 2005 Examiner: Manschot, J

CATEGORIES OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same Category
A: technological background
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T: theory of principle underlying the invention (non-prepublished)
E: colliding patent application
D: document cited in the application
L: citation for other reasons
....
&: member of the same patent family; corresponding document

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03P09694

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2002/0198447 A1**
Van Muiswinkel et al. (43) **Pub. Date: Dec. 26, 2002**

(54) **AUTOMATIC PRESCRIPTION OF TOMOGRAPHIC IMAGING PARAMETERS**

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(21) Appl. No.: **10/150,136**

(22) Filed: **May 16, 2002**

(30) **Foreign Application Priority Data**

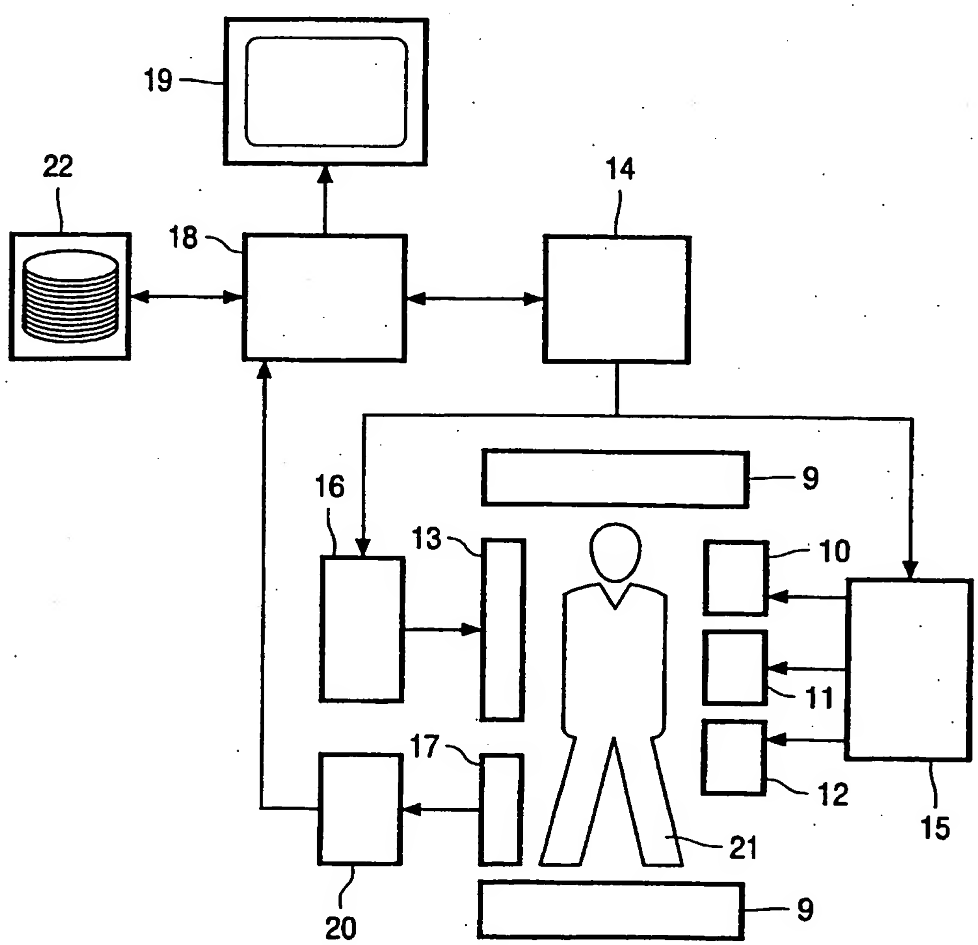
May 16, 2001 (EP) 01201831.3

Publication Classification

(51) **Int. Cl.**[7] **A61B 5/05**
(52) **U.S. Cl.** **600/410**

(57) **ABSTRACT**

The invention relates to a method for prescription of scanning parameters determining the orientation and location of tomographic imaging planes. The invention facilitates the process of re-scanning a patient at different times. This is achieved by the computation of the current orientation and location of the patient relative to his or her orientation and location during a previous examination by matching (3) a current reference scan image (1) with the image data of a corresponding previous reference scan (2). The current examination scanning parameters are calculated by adjusting the scanning parameters of the previous examination in accordance with the relative position of the patient during the current examination.



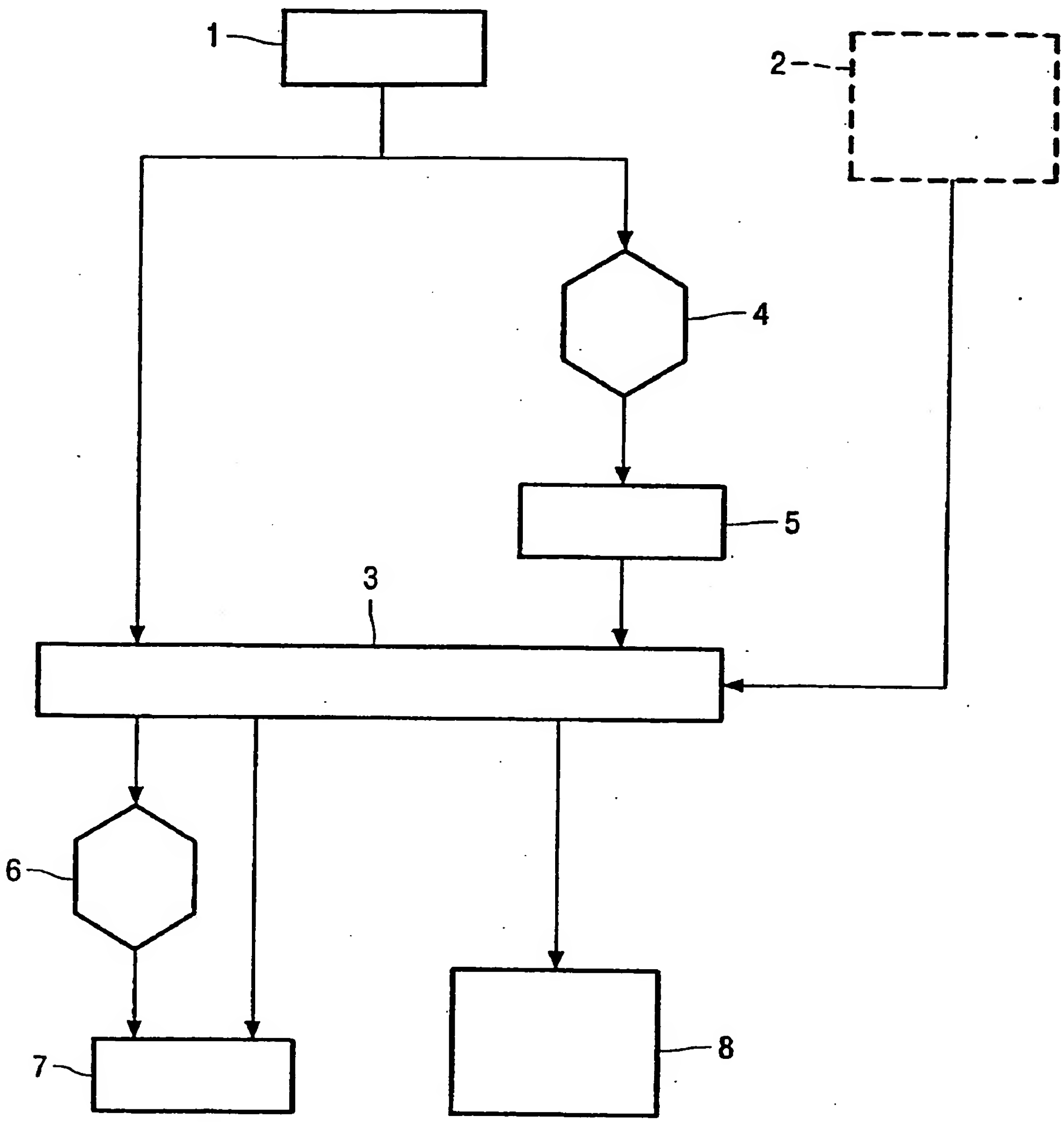


FIG. 1

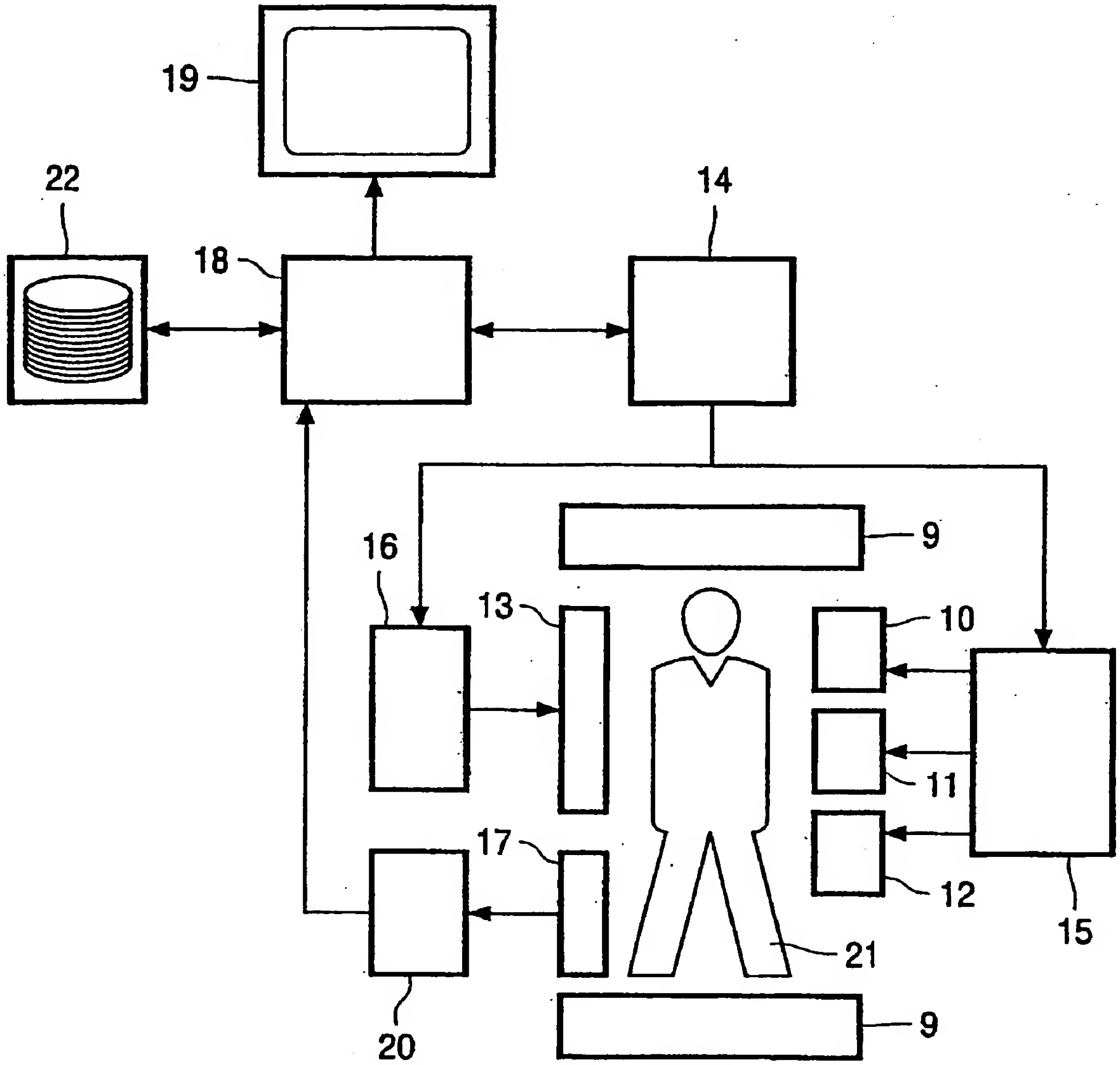


FIG. 2

AUTOMATIC PRESCRIPTION OF TOMOGRAPHIC IMAGING PARAMETERS

BACKGROUND

[0001] The invention relates to a method for prescription of scanning parameters determining the orientation and location of tomographic imaging planes, wherein a current reference scan of an object is performed, the image data of the reference scan being analyzed, thereby extracting geometric data defining the current orientation and location of the examined object in the scanner, and wherein scanning parameters for one or more current examination scans are computed by relating the current geometric data of the examined object to the corresponding geometric data of the same object during a previous examination.

[0002] Furthermore, the invention relates to a computer program for carrying out the method of the invention and a tomographic imaging apparatus operating according to this method.

[0003] In medical imaging, such as magnetic resonance imaging (MRI) or computer tomography (CT), an image of a section or slice of a region of interest of a patient is reconstructed from the magnetic resonance signals (MRI) or the X-ray beam projections (CT). Typically, the scanning of patients for medical purposes is performed according to manual prescriptions of the scanning parameters determining the orientation and location of the imaging planes. Because of the variability in the selection of the most appropriate angulation and off-center parameters of the imaging planes it is a difficult task to achieve good reproducibility for scans of the same patient which are repeated at different examination sessions at different times.

[0004] There is a need to facilitate the process of re-scanning a patient at different times. This is because there are several groups of patients with diseases, like for example cancer, multiple sclerosis, Alzheimer's disease, and others, which have to be examined several times in order to assess the progression of the disease and the success of the applied therapy. An accurate analysis of the development requires precise prescription of scanning parameters. Furthermore, accurate re-scanning also plays an important role in interventional radiology. Current practice is to send the patient for a repeated tomographic examination with the imaging results of the previous examinations on film. From these images the radiologist or the operator of the tomographic apparatus then usually tries to trace back the scanning parameters of the previous examination. This proceeding is very laborious, cumbersome and little precise, particularly if several angulations of different scans are involved. The totally manual prescription of scanning parameters for re-scanning of a patient thus takes a long time and is not very accurate in terms of positioning of the imaging planes. Often more than one attempt is required before reasonable results are obtained.

[0005] Therefore it is readily appreciated that there is a need for methods which enable a more or less automated prescription of scanning parameters for repeated rescanning of the same patient, thereby minimizing the involvement of human operators. Such methods are particularly useful if they directly provide a set of scanning parameters depending on the corresponding parameters of previous examinations.

[0006] Such a method is for example described in U.S. Pat. No. 6,195,409 B1. According to this known method one or more so-called localizer scans are performed initially. Thereafter, these localizer images are analyzed in order to extract structural information about the examined object, such as size, location and orientation of the object or organ. As a result of this analysis, an abstract, schematic description (a model) of the examined object is obtained. This abstract schematic description is then matched with a so-called reference template which additionally contains information about the location of the imaging planes and the scanning parameters. The above mentioned model is an abstract, schematic description of the object of interest consisting of geometric and structural information corresponding to geometric and physical attributes of the object. The model comprises for example coordinates identifying characteristic features of the examined object, such as the tip of the nose, an eye and other reference points which correspond to characteristic anatomic structures. Extracting the parameters of the model from the localizer images involves geometric transformations which are iteratively performed until an optimal fit between the generic model and the particular image data is obtained. Once the model is matched with the image data, the various imaging planes are determined from the planes of the template, thus allowing the automated prescription of new scanning parameters.

[0007] The main drawback of the above technique is based on the use of the abstract, schematic model. The implementation of the complex matching procedure of the model with the reference image of the examined object is difficult or even not practicable, particularly on tomographic scanners with limited computing capacities. The generic model is most appropriate to automatically select optimal, standard imaging planes for any individual patient, but it is not optimally suited to meet the specific requirements of re-scanning the same patient repeatedly at different examination sessions at different times. This is because the known method makes no use of individual characteristic features of a single individual which can advantageously be exploited if the same examination of the same patient has to be performed again and again. Indeed, it is already current practice of the operators of tomographic scanners to use such individual features to manually trace back the scanning parameters of the previous examinations. In contrast to this, the known method will fail to accurately find the same orientation and location of the imaging planes again if changes of the object of interest occur between the examinations, as it is typically the case during the progression of a disease like cancer, multiple sclerosis and others. In such situations not only the orientation and position of the examined object in the scanner but also its physical properties have changed during the period between the examinations.

SUMMARY

[0008] It is consequently the primary objective of the present invention to provide an improved technique for the prescription of scanning parameters for tomographic imaging.

[0009] It is a further object to enable a fully or semi-automated prescription of scanning parameters which is optimally suited for repeated re-scanning of the same patient, thereby making use of characteristic anatomical properties of the examined individual.

[0010] In accordance with the present invention, a method for prescription of scanning parameters of the type specified above is disclosed, wherein the aforementioned problems and drawbacks are avoided by the computation of the current orientation and location of the object relative to its orientation and location during the previous examination by matching the current reference scan image data with the image data of a previous reference scan, the current examination scanning parameters being calculated by adjusting the scanning parameters of the previous examination in accordance with the relative orientation and location of the object during the current examination.

[0011] The present invention enables to perform tomographic scanning with the relation between the geometries of the patient and the imaging planes being equal at each repeated examination session. This is achieved by the registration of reference scan image data which is employed to establish a well defined initial scanning geometry. The reference scan is performed as well during the previous as during the current examination with sufficient anatomical coverage to safely assess the orientation and location of the patient in the scanner. The previous angulation and off-center parameters, which were for example determined when the examination was manually planned at the first session, are reestablished at the current examination by comparison of the previous and the current reference scan image data. For the method of the invention, which in practice has to be implemented on a computer, it is needed to have the digital data of the previous examinations available. This requirement can easily be met by adding the necessary image data to the corresponding entry of a patient database as it is well known in the art.

[0012] The method of the present invention is simple, fast, precise and very robust in terms of assessing the orientation and location of the examined object in the scanner because it makes use of the characteristic features of the same object which has already been examined at a previous session. No difficult model reconstruction, as it is described in the above cited U.S. patent, is needed. It is particularly advantageous that the investigation of the relative geometric data can be performed easily and fast by taking low resolution images of a volume of interest which has been defined during the previous examination of the patient. Once the relative orientation and location of the patient is established, the new scanning parameters are prescribed by simply adjusting the corresponding parameters of the previous examination accordingly. The previous scanning parameters can be made available most easily by including them into the patient database entry.

[0013] With the method of the invention it is useful if the matching of the current and previous reference scan image data is performed by identification of three or more corresponding landmark points in the scan volumes of both the current and previous reference scans.

[0014] Three landmark points in space, which might for example represent the location of characteristic anatomic features, span a plane whose orientation (angulation) relative to the coordinates of the scan volume of the reference scan is known for both the previous and the current examination. The off-centers are known for both, too. From the previous data, including the coordinates of the landmark points relative to the reference scan volume and the orientations and locations of the examination imaging planes relative to the geometry of the reference scan, the scanning parameters for the subsequent current examination are derived by adding the relative off-centers and angulations of the plane spanned by the landmark points of the current reference scan in order to obtain equal imaging planes for the current examination. Optionally more than three landmark points might be identified in order to increase the accuracy of the method. Three landmark points are sufficient to compensate for translations and rotations of the examined object between subsequent examinations. If more than three landmark points are employed also stretching and bending is taken into account.

[0015] The above described identification of landmark points can be carried out either manually by an operator of the scanning device or automatically by means of an appropriate image recognition or pattern matching algorithm. According to the method of the present invention, the matching of the current and previous reference scan image data is in this case performed by recognition of characteristic features in the images of both the current and the previous reference scans.

[0016] It is advantageous to carry out the matching of the current and previous reference scan image data by identification of landmark points, because in this case the scanning parameters of the previous and current reference scans do not necessarily have to be identical. When using anatomical landmarks, variations in the field of view or in the contrast of the images can easily be dealt with. It is also possible to employ any diagnostic anatomical scan as reference scan images for the identification of the anatomical landmarks as long as the position of the imaging planes relative to the geometry of the landmark points is known. Therefore it is useful if the relative geometry of the examination imaging planes and the anatomical landmark points is also stored in the patient database, thereby enabling the scanning parameters to be calculated automatically once the landmark points are identified in the current reference image data.

[0017] As an useful alternative, by which the involvement of a human operator is completely eliminated, it is also possible to perform the matching of the current and previous reference scan image data by finding a geometric transformation that minimizes the differences between the two images. This can be done by application of standard algorithms which iteratively compute the parameters of the geometric transformation until the difference between the two reference images is minimal. The resulting geometric transformation is defined by rotation angles and a translation vector representing the relative orientation and location of the patient with respect to the previous examination. These data can directly be used to compute the scanning parameters of the current examination by applying the same geometric transformation to the scanning parameters of the previous examination.

[0018] A computer program adapted for carrying out the method of the present invention employs a matching algorithm which processes the image data of the current reference scan, thereby extracting geometric data defining the current orientation and location of the examined object in the scanner, and further relating the current geometric data of the examined object to the corresponding geometric data of the same object during a previous examination. This

matching algorithm computes the current orientation and location of the object relative to its orientation and location during the previous examination by matching the current reference scan image data with the image data of a corresponding previous reference scan, the current examination scanning parameters being calculated by adjusting the scanning parameters of the previous examination in accordance with the relative orientation and location of the object during the current examination.

[0019] Such a computer program can advantageously be implemented on any common computer hardware which is presently in clinical use for the control of tomographic imaging apparatus, such as for example MRI or CT scanners. The computer program can be provided on suitable data carriers, such as CD-ROM or diskette. Alternatively, it can also be downloaded by a user from an internet server.

[0020] For a practical implementation of such a computer program, both the current and the previous reference images are presented to the operator by means of a computer display device, thereby enabling the operator to perform the matching of the current and the previous reference image data interactively by identifying three or more corresponding landmark points in the scan volumes of both the current and previous reference scans.

[0021] The computer program can for example provide a user interface with multiple viewports to present different three dimensional views of the examined object to the operator. Both the previous and the current reference scan images are displayed in different viewports. A very intuitive method for facilitating the matching of the previous and the current reference scan images is to display slices through different anatomical landmarks in the viewports. The orientations and locations of these slices can be interactively manipulated by the user. The matching procedure is completed when the user decides that corresponding slices which are displayed in the different viewports have the same locations and orientations relative to the position of the examined object in the images of both the previous and the current reference scans.

[0022] In order to obtain maximum accuracy, it is furthermore advantageous if the matching of the current and previous reference scan image data is refined by automatic recognition of characteristic features in the images of both the current and the previous reference scans and/or by finding a geometric transformation that minimizes the differences between the two images. Thus an optimal result is obtained by alternately applying an interactive, user-controlled and a fully automatic matching procedure. It is possible to start the matching of the previous with the current reference scan image data with either a user-controlled or an automatic matching method. In case of large differences between the previous and the current examination, which can for example be due to the progress of the disease or to the resection of a tumor, the automatic registration of the position of the patient in the scanner may fail. In such situations the user may decide to start the matching procedure interactively and subsequently refine the localization by an automatic matching algorithm.

[0023] Interactive matching by finding a geometric transformation that minimizes the differences between the two images can be implemented by the visualization of subtraction images. If the same scanning parameters are employed for both the previous and the current reference scans, the matching can be indicated to the user by displaying a difference image of the previous and the current reference scans. The optimal transformation is found if the difference image shows a more or less homogeneous minimum intensity.

[0024] It is possible to incorporate the method of the present invention in dedicated tomographic imaging apparatus, such as MRI or CT devices, comprising a scanner and a computer, wherein the scanner comprises means for generating tomographic images according to scanning parameters being prescribed by the computer, and wherein the computer comprises a memory and a program control which operates according to the method of the present invention.

DRAWINGS

[0025] The following drawings disclose preferred embodiments of the present invention. It should be understood, however, that the drawings are designed for the purpose of illustration only and not as a definition of the limits of the invention.

[0026] In the drawings

[0027] **FIG. 1** shows a representation of the method of the present invention as a block diagram;

[0028] **FIG. 2** shows a magnetic resonance system adapted to operate according to the method of the present invention.

DESCRIPTION

[0029] **FIG. 1** represents the workflow of a typical implementation of the present invention. It starts with the registration of a survey scan image 1. For this purpose it is sufficient to take low resolution images of a volume of interest which is selected to allow for a reliable assessment of the position of the patient in the scanner. After step 1 it is either possible to start directly with the extraction of the required geometric data by taking the survey scan 1 as current reference scan image data in the sense of the present invention. In this case, the image data from a previous examination 2, which is stored in the patient database entry, is used to perform the matching of the current reference scan image with the image data of the corresponding previous reference scan in step 3. As an alternative, the image data of the survey scan 1 is transferred to a plan scan tool which is used by the operator of the tomographic scanner in step 4 to interactively plan the subsequent scanning of the patient. In step 5, either a full anatomical examination scan or just a short reference scan is initiated in accordance with the prescription of the operator in step 4. Thereafter, the actual matching of the previous and the current reference image data is carried out in step 3. The current reference scan image data can either be the survey image of step 1 or at least parts of the image data generated in step 5. The corresponding previous reference scan image data 2, which are provided in digital form by the patient database, are selected automatically.

[0030] There are different possibilities of computing the current orientation and location of the examined object relative to its orientation and location during the previous examination. As described above, both the current and the previous reference scan images can be presented to the

operator who performs the matching interactively by identifying three or more corresponding landmark points in the respective images. Additionally, the matching of the reference scan image data can be refined by automatic recognition algorithms or by finding a geometric transformation that minimizes the differences between the previous and the current images. Depending on the scanning parameters of the reference scans it might be necessary to interpolate the image data in accordance with the scanning parameters of the previous examination session 2 before the actual matching of corresponding images can be carried out.

[0031] Once the relative orientation and location of the patient with respect to the previous examination 2 is settled, also the calculation of the current examination scanning parameters is performed in step 3. The corresponding scanning parameters of the previous examination 2 are again extracted from the patient database and adjusted in accordance with the relative position of the patient during the current examination.

[0032] Thereafter, the angulations and off-center parameters which have been computed in step 3 can be presented to the operator by means of a plan scan tool in step 6. The operator can check and confirm the results of the matching procedure. He is also enabled to further adjust the scanning parameters manually before the actual examination scanning is initiated in step 7. It is also possible to start the scanning procedure 7 immediately without any involvement of the operator. If a full anatomical scan was performed in step 5, redundant scanning is avoided by computing "re-sliced" images based on the image data in step 8 in accordance with the image plane orientations and locations which have been computed in step 3. This allows for the application of the method of the invention as a mere post-processing of conventionally registered image data.

[0033] A magnetic resonance system as shown in **FIG. 2** is suitable for carrying out the method of the invention. It includes a coil 9 for generating a steady, uniform magnetic field, gradient coils **10**, **11** and **12** for generating gradient pulses in the x, the y and the z direction, and an RF transmission coil **13**. The temporal succession of the gradient pulses is controlled by means of a control unit **14** which communicates with the gradient coils **10**, **11** and **12** via a gradient amplifier **15**. Furthermore, the control unit **14** is connected to the RF transmission coil **13** via an RF transmission amplifier **16**, so that powerful RF pulses can be generated. The MR signals, which are excited by the RF pulses, are registered by a RF receiving coil **17**. The system also includes a reconstruction unit in the form of a microcomputer **18** as well as a visualization unit **19** which may be a graphic monitor. The spin resonance signals, which are registered by the RF receiving coil **17** are demodulated and amplified by a receiver unit **20**. In the reconstruction unit **18** the spin resonance signals are subjected to Fourier analysis in order to generate images of regions of interest of a patient **21**. The method of the invention is implemented as a computer program in the reconstruction unit **18**. The reconstructed current reference images are processed according to the invention. Therefore, the previous imaging data, which is required for the matching procedure, is included from a patient database server **22**. The reconstruction unit **18** transfers the scanning parameters, which are computed in accordance with the present invention, to the control unit **14**, which initiates the desired re-scanning procedure of the patient **21**.

[0034] The invention has been described with reference to the preferred embodiment. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. Method for prescription of scanning parameters determining the orientation and location of tomographic imaging planes, wherein a current reference scan (1) of an object is performed, the image data of the reference scan being analyzed, thereby extracting geometric data defining the current orientation and location of the examined object in the scanner, and wherein scanning parameters for one or more current examination scans (7) are computed by relating the current geometric data of the examined object to the corresponding geometric data of the same object during a previous examination (2), wherein the current orientation and location of the object relative to its orientation and location during the previous examination (2) is computed by matching (3) the current reference scan image data with the image data of a previous reference scan, the current examination scanning parameters being calculated by adjusting the scanning parameters of the previous examination (2) in accordance with the relative orientation and location of the object during the current examination.

2. Method of claim 1, wherein the matching of the current and previous reference scan image data is performed by identification of three or more corresponding landmark points in the scan volumes of both the current and previous reference scans.

3. Method of claim 1, wherein the matching of the current and previous reference scan image data is performed by recognition of characteristic features in the images of both the current and the previous reference scans.

4. Method of claim 1, wherein the matching of the current and previous reference scan image data is performed by finding a geometric transformation that minimizes the differences between the two images.

5. Computer program which prescribes the parameters defining the location and orientation of tomographic imaging planes for one or more current examination scans by processing the image data of a current reference scan, thereby extracting geometric data defining the current orientation and location of the examined object in the scanner, and further relating the current geometric data of the examined object to the corresponding geometric data of the same object during a previous examination, wherein the current orientation and location of the object relative to its orientation and location during the previous examination is computed by matching the current reference scan image data with the image data of a corresponding previous reference scan, the current examination scanning parameters being calculated by adjusting the scanning parameters of the previous examination in accordance with the relative orientation and location of the object during the current examination.

6. Computer program of claim 5, wherein both the current and the previous reference images are presented to a user by

means of a computer display device, thereby enabling the user to perform the matching of the current and the previous reference image data interactively by identifying three or more corresponding landmark points in the scan volumes of both the current and previous reference scans.

7. Computer program of claim 6, wherein the matching of the current and previous reference scan image data is refined by automatic recognition of characteristic features in the images of both the current and the previous reference scans and/or by finding a geometric transformation that minimizes the differences between the two images.

8. Tomographic imaging apparatus comprising a scanner and a computer, wherein the scanner comprises means for generating tomographic images according to scanning parameters being prescribed by the computer, and wherein the computer comprises a memory and a program control wherein a current reference scan (1) of an object is performed, the image data of the reference scan being analyzed, thereby extracting geometric data defining the current orientation and location of the examined object in the scanner, and wherein scanning parameters for one or more current examination scans (7) are computed by relating the current geometric data of the examined object to the corresponding geometric data of the same object during a previous examination (2), wherein the current orientation and location of the object relative to its orientation and location during the previous examination (2) is computed by matching (3) the current reference scan image data with the image data of a previous reference scan, the current examination scanning parameters being calculated by adjusting the scanning parameters of the previous examination (2) in accordance with the relative orientation and location of the object during the current examination.

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1027333 O5PW694

LITERATUUR KOPIEEN

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

B10

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 September 2004 (23.09.2004)

PCT

(10) International Publication Number
WO 2004/080309 A2

(51) International Patent Classification[7]: A61B 6/03

(21) International Application Number: PCT/IB2004/000527

(22) International Filing Date: 27 February 2004 (27.02.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
03100589.5 10 March 2003 (10.03.2003) EP

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM,

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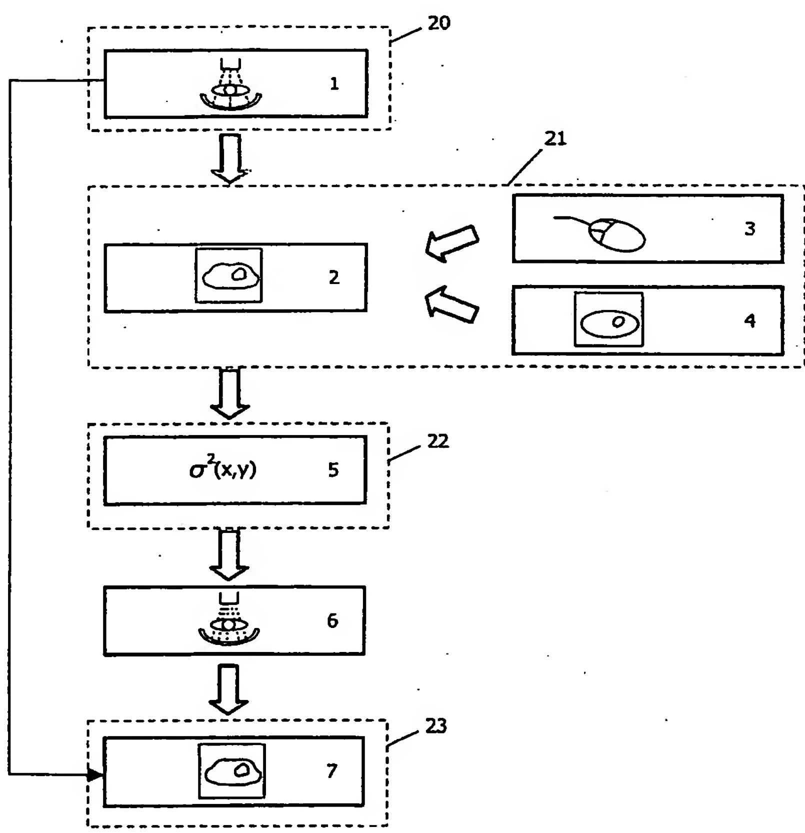
(54) Title: DEVICE AND METHOD FOR ADAPTING THE RECORDING PARAMETERS OF A RADIOGRAPH



(57) Abstract: The invention relates to a method of adapting imaging parameters for a computer tomographic radiograph of a body volume, comprising the following steps: obtaining a three-dimensional pilot radiograph with a low dose of radiation (1); determining a region of interest and a desired image quality in the pilot radiograph (2) with the aid of a patient model (4) or interactively (3); determining optimal imaging parameters (5); generating an X-ray image using the determined imaging parameters (6). Optionally, the X-ray image is combined (7) with the pilot radiograph.

WO 2004/080309 A2

TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Device and method for adapting the recording parameters of a radiograph

The invention relates to a method of adapting the imaging parameters of a medical radiograph of a body volume and also to a control device and X-ray apparatus designed to carry out the method.

US 6 195 409 B1 discloses a method of adapting the imaging location of a computer-tomographic radiograph, in which firstly a pilot image is taken of a patient's body volume that is to be imaged. Structure information is then derived from the pilot image in order to obtain a model of the imaging area which is then adapted to a stored patient model. The positions of imaging regions of interest that are known in the patient model, for example the profile of the spinal column, can thus be transferred onto the model. From this, it is possible to determine the geometric settings of the X-ray apparatus, which image the selected region of interest of the actual body. An adaptation of parameters that affect image quality is not described.

Typically, when generating radiographs using for example a computer-aided tomography scanner, predefined protocols are used which prescribe a set of parameters (current of the X-ray tube, voltage of the X-ray tube, etc.) for each part of the body and the nature of the disorder that is to be investigated. These standard settings may accordingly be adapted in particular cases in accordance with the knowledge of the user, for example in the case of very large patients or in the case of small children. In the past, many improvements to X-ray technology have been developed, for example a reduction of the dose by means of adaptive filtering (WO 02/11068 A1), by modulating the current of the X-ray tube (EP 1 172 069 A1), by repeated scans at different aperture settings and the like. These developments comprise a previously unknown flexibility in the definition of the imaging protocol and in particular in the optimization of the image quality for a region of interest. Nevertheless, the integration of this method into standard protocols is difficult on account of the large number of degrees of freedom. In particular, the high level of flexibility makes it practically impossible for the user of a CT system to define a imaging protocol which delivers the desired image quality at a minimum dose of radiation.

Against this background, it is an object of the present invention to provide means for adapting the imaging parameters of a medical radiograph of a body volume, in which a desired image quality can be achieved in a region of interest with minimum exposure to radiation.

This object is achieved by a method having the features of claim 1, by a control device having the features of claim 10, and by an X-ray apparatus having the features of claim 16. Advantageous refinements are given in the dependent claims.

The method according to the invention is used to adapt the imaging parameters of a medical radiograph of a body volume, where the imaging may in particular be a computer-tomographic two-dimensional or three-dimensional imaging. The method comprises the following steps:

a) The obtaining of a "model" or representation of the body volume in question. The model is typically described by a two-dimensional or three-dimensional data record.

b) The determination of a region of interest on the basis of the abovementioned model or within the model. This determination may take place for example interactively by the user of the X-ray apparatus or automatically.

c) The determination of imaging parameters for the region of interest, which are optimal with respect to a predefined criterion. The model from step a) is preferably used to define the imaging parameters.

d) The generation of an X-ray image of the region of interest of the body volume, based on the determined optimal imaging parameters.

The method described has the advantage that by using a model of the body volume it is possible to locate a region of interest and determine a set of optimal imaging parameters tailored thereto. The parameters are therefore defined specifically for the individual case, but their determination requires that the examined patient be exposed to radiation only to a minimum extent.

The imaging parameters which can be adapted by means of the method may include in particular the applied dose of radiation, the voltage of the X-ray tube, the current of the X-ray tube, the aperture setting of the X-ray apparatus, the filter setting of the X-ray apparatus, the imaging duration and/or the imaging area. In particular, the imaging

parameters can define not only the geometry of the X-ray image generated but also those variables that affect image quality.

The obtaining of a model of the body volume according to step a) may take place in various ways. According to a first embodiment, the model of the body volume is obtained from a "pilot" radiograph with a low dose of radiation. Preferably, the pilot radiograph gives a three-dimensional representation of the recorded body volume. By means of the pilot radiograph, a model that coincides exactly with the individual anatomy can be generated while exposing the patient to a minimum dose of radiation, and this model is then available for defining a region of interest and optimal imaging parameters.

The abovementioned pilot radiograph is preferably used to generate the X-ray image in step d) of the method, so that the information contained therein and obtained under exposure to radiation – albeit a low dose – is not lost.

According to another embodiment of step a), the model of the body volume is obtained from stored previous radiographs of the body volume. In many cases, previous radiographs will already have been taken of a patient that is to be examined, and these can be called up from an archive. By using these existing data, a model which is matched individually to the patient can be obtained without extra exposure to radiation.

Furthermore, a standardized patient model may also be used for step a) of the method. Said standardized patient model may consist for example of stored radiographs of a reference patient or be a mathematical model defined in abstract terms. The patient model also has the advantage that it can be obtained without the patient under examination having to be exposed to radiation.

The above-described embodiments for obtaining the model by means of stored patient radiographs or a mathematical patient model are optionally adapted to at least one current radiograph of the body volume. Such a two-dimensional or three-dimensional radiograph is preferably obtained with the patient being exposed to a very low dose of radiation and is used to adapt the aforementioned models individually to the present situation.

According to a preferred embodiment of the method, the X-ray image of the body volume that is generated in step d) is reconstructed from X-ray projection images that have been taken from various directions. The optimal imaging parameters defined in step c) in this case preferably include values for a minimum aperture opening of the X-ray apparatus, which is defined such that the region of interest is detected along with a border area of predefined width around the region in all projection images. The border area around the region of interest is necessary to ensure a sufficient imaging quality within the region of

interest. It is typically only a few millimeters. The aperture setting on the one hand ensures a complete and qualitatively good imaging of the region of interest and on the other hand, on account of the minimality, ensures that the radiation to which the patient is exposed is limited to a minimum dose.

Another embodiment of the invention is likewise based on the fact that the X-ray image is reconstructed from X-ray projection images from various directions. In this case, the current of the X-ray tube (as an optimal parameter defined in step c) is modulated as a function of the projection direction of the X-ray projection images such that an image quality measure based on the region of interest is observed in the projection images. Such a modulation of the current of the X-ray tube may contribute to further minimizing the amount of radiation to which the patient is exposed since the radiation dose is always set, as a function of the direction, only to the level required to ensure the desired image quality.

Preferably, maximum doses of X-ray radiation that have to be observed are also taken into account in the determination of optimal imaging parameters in step c) of the method. Such maximum doses may be prescribed for example in the case of certain disorders or for specific organs and have a higher priority than a desired imaging quality.

The invention furthermore relates to a control device for an X-ray apparatus for generating X-ray images of a body volume, where the control device comprises the following components:

- a model unit for obtaining a model of the body volume;

- a definition unit for determining a region of interest on the basis of a model provided by the model unit;

- a parameter determination unit for determining optimal imaging parameters for the region of interest determined by the definition unit.

The control device may be formed for example by a data processing unit (computer, microprocessor) having data and program memories. It can be used to carry out the abovementioned method so that the advantages thereof can be obtained. The control device is preferably designed such that it can also carry out the abovementioned variants of the method.

In particular, the control device may include a user interface (keyboard, mouse, monitor, disk, etc.) via which a user can provide the control device with data or receive data from the control device. The user interface is preferably designed such that it permits interaction with the definition unit so that a user can interactively define a region of interest.

Furthermore, the control device may include an interface for the connection of an X-ray radiation source and/or an X-ray detector. Via this interface the control device can then receive data from the aforementioned devices (particularly raw imaging data from the X-ray detector) and transmit information and control commands to said devices.

The control device may furthermore comprise an image processing unit coupled to the model unit, for processing (raw) X-ray data to form an X-ray image. By virtue of the coupling to the model unit, it is possible to also take into account, in the processing, information from the model unit, such as a pilot radiograph for example.

The imaging parameters defined by the parameter determination unit may be, in particular, the applied dose of radiation, the voltage of the X-ray tube, the current of the X-ray tube, the aperture setting, the filter setting, the imaging duration and/or the imaging area.

The model unit of the control device is optionally designed to obtain the model of the body volume from a preferably three-dimensional pilot radiograph with a low dose of radiation.

The invention furthermore relates to an X-ray apparatus for generating X-ray images, which comprises the following components:

- an X-ray radiation source for generating a bundle of X-rays;

- an X-ray detector for the locally resolved measurement of the X-ray radiation after passing through the body of a patient;

- a data processing unit connected to the X-ray radiation source and the X-ray detector, for controlling the image generation and for processing the radiographs obtained.

The data processing is designed to carry out the following steps:

- obtaining a model of the body volume;

- determining a region of interest on the basis of the model;

- determining optimal imaging parameters for the region of interest;

- generating an X-ray image of the region of interest of the body volume based on the optimal imaging parameters.

The X-ray apparatus can be used to carry out the abovementioned method so that the advantages thereof are obtained. The X-ray apparatus or the data processing unit thereof is preferably designed such that it can also carry out the abovementioned variants of the method.

The invention will be further described with reference to examples of embodiments shown in the drawings to which, however, the invention is not restricted.

Fig. 1 is a flowchart of the method according to the invention for adapting imaging parameters.

Fig. 2 is a schematic section through a body volume with a region of interest and the relevant variables for calculating an aperture setting.

Fig. 1 shows the successive steps of a method according to the invention for optimizing the imaging protocol of an X-ray image. Hereinbelow, the case of computer-aided tomography will be considered by way of example, although the method is not restricted thereto. Furthermore, fig. 1 shows in dashed lines the components of a control device in which the corresponding method steps can be carried out. The control device may in this case be in particular a data processing unit with associated data and program memories. The various components of the control device are in this case formed by various modules of a program running on the data processing unit.

In the first step 1 or in a model unit 20 a three-dimensional pilot radiograph is recorded or reconstructed with a low dose of radiation in order to obtain a model of the body volume that is to be examined.

In the next step 2 a diagnostically relevant region of interest (cf. reference 12 in fig. 2) is defined from this pilot radiograph. Furthermore, a desired image quality is defined for this region of interest, and this may be effected for example by specifying the maximum noise. The region of interest and the image quality may be defined interactively by the operator of the X-ray apparatus (step 3). Alternatively, they can also be defined, according to step 4, with the aid of a predefined, stored patient model comprising application-specific predefined regions and image quality parameters, where the patient model is adapted to the pilot radiograph for example by means of elastic registering (cf. P. Rösch et al., "Robust 3D deformation field estimation by template propagation", Proc. of MICCAI 2000, LNCS 1935). Steps 2, 3 and 4 are carried out in a definition unit 21 of the control device.

Using the information determined, the imaging parameters contained in a reference protocol are optimized (see below) in step 5 or in a parameter determination unit 22, in order to reduce the radiation dose while at the same time ensuring the desired image quality. The optimal imaging parameters determined in this way are then used as a basis in the generation of the actual X-ray image in step 6.

In step 7 or in an image processing unit 23, the resulting data of the X-ray image from step 6 are optionally combined with the data obtained with a low dose of radiation in step 1, and the final X-ray image is reconstructed.

Besides the optimization of the image quality in a defined region of interest, it may also be important to reduce or limit the dose for specific organs during the obtaining of the image. This information may be taken into account in step 2 of fig. 1. The subsequent adaptation and optimization of the imaging protocol is then directed at a compromise between image quality and dose reduction for specific organs or at a maximum achievable image quality in the region of interest while at the same time satisfying dose limitations in all regions.

The model can also be obtained in step 1 by using previously obtained tomographic patient images from an archive or by using tomographic data from a reference patient. In these two cases, data defined interactively on the models, such as a region of interest for example, must be adapted to the patient during the diagnosis. This may be effected for example by one or two pilot images being generated at different angles, said pilot images being adapted two-dimensionally or three-dimensionally to the previous patient data (first case) or to the reference data (second case) (cf. G.P. Penney, J.A. Little, J. Weese, D.L.G. Hill, D.J. Hawkes, "Deforming a preoperative volume to represent the intraoperative scene", Comput. Aided Surg. 2002, 7(2), 63; G.P. Penney, J. Weese, J.A. Little, P. Desmedt, D.L.G. Hill, D.J. Hawkes, "A comparison of similarity measures for use in 2D-3D medical image registration", IEEE Trans. Med. Imag. 1998, 17(4), 586).

An important step in the abovementioned method is the determination of optimized imaging parameters in step 5. By way of example, one of many possible embodiments of this optimization step 5 will be described below in more detail.

Fig. 2 in this respect shows the circular field of view 11 of a CT scanner rotating in the direction of the arrow 14, said CT scanner containing the body 10 of a patient. Within the body 10 there is a region of interest 12 shown in gray, and this region of interest is to be examined and (exclusively) imaged in detail. In order to simplify the description, fig. 2 refers to a geometry having parallel X-rays and to the obtaining of a single sectional image. The X-ray radiation X passes through the body volume 10 at an angle θ relative to the horizontal. In one complete X-ray scan, a series of such projection images are generated over an interval of 180° of the projection angle θ. The individual projection images are described by the projection function $p(\theta,\xi)$, where ξ is the distance measured with respect to a ray running through the center point M of the field of view 11 (at the same time center of rotation

of the CT scan). The aim of a computer-tomographic imaging is to reconstruct, from the projection images p of all projection directions θ, the image points f (x,y) of the imaged region, where x and y are coordinates with respect to the center point M of the field of view. The equations (cf. EP 1 172 069 A1)

$$f(x,y) = \int d\theta\, d\xi\; p(\theta,\xi)\; k(x\cos\theta + y\sin\theta - \xi)$$

$$\sigma^2(x,y) \propto \int d\theta\, d\xi\; I^{-1}(\theta,\xi)\; e^{p(\theta,\xi)}\; k^2(x\cos\theta + y\sin\theta - \xi)$$

may be used to derive a specific strategy for determining optimal imaging parameters for step 5 of the method of fig. 1. The variable $\sigma^2(x, y)$ is in this case the noise of the reconstructed image f (x,y) in the case of a filtered back-projection with the filter core k(ξ). The variable I(θ,ξ) describes the current of the X-ray tube during the imaging of the image, where the dependence on the projection angle θ detects any modulation of the current of the X-ray tube to minimize the radiation dose. The (virtual) dependence of the X-ray tube current I on the coordinate ξ takes into account the effect of apertures 13a, 13b or filters and the resulting variation in the radiation intensity within a projection image p(θ,ξ) in a given projection direction θ.

Since the filter core k(ξ) decreases rapidly as the value |ξ| of its argument increases, the intensity of X-rays more than a defined distance r away from the region of interest 12 can be considerably reduced without thereby notably increasing the noise in the region of interest 12. Against this background, it is possible to define the position of two semi-transparent apertures 13a, 13b as a function of the region of interest 12, as described below.

Fig. 2 shows, for a given projection angle θ, two X-rays having the coordinates ξ_l (θ) and ξ_r (θ), which make contact with the region of interest 12 on its left and right side, respectively. The greater of the two absolute values of said coordinates assumes a minimum value ξ_{min} at a defined projection angle θ_{min}:

$$\xi_{\min} = \min_{\theta} \max\left\{ |\xi_l(\theta)|, |\xi_r(\theta)| \right\} = \max\left\{ |\xi_l(\theta_{\min})|, |\xi_r(\theta_{\min})| \right\}$$

Furthermore, the maximum distance d_{max} from the center of rotation M of the CT scan which a point Q of the region of interest 12 may have is determined.

Using the two variables ξ_{min} and d_{max} and also the distance r for which the amount of X-ray radiation in the reconstructed image is approximately negligible, the positions of the two apertures 13a, 13b are determined as follows:

$$p_1 = \xi_{\min} + r, \qquad p_2 = d_{\max} + r$$

Using these aperture positions p_1 and p_2, projections from the angular range [θ_{min}, θ_{min}+180°] are obtained by switching the current of the X-ray tube on during the rotation of the X-ray tube in the direction of the arrow 14 at the angular position θ_{min} and switching it off again when the position θ_{min}+180° is reached.

Sectional artefacts within the reconstructed image, which are represented by singularities in the quality σ^2 of the image, may be avoided by using the pilot image obtained at a low dose in step 1 of fig. 1, which was used to plan and optimize the imaging protocol, to complete the data obtained.

The method described provides a means of optimizing a imaging protocol which allows the adaptation of a protocol to an individual patient, a local definition of image quality parameters and a local limitation of the radiation dose used during a CT imaging. Firstly, pilot images or 3D images are obtained while exposing the patient to a low dose of radiation. Within these images, the diagnostically relevant regions and the desired image quality are defined. Using this information, the imaging parameters of a reference protocol, such as the aperture settings and the modulation of the current of the X-ray tube for example, can then be optimized, in order to reduce the dose while ensuring the image quality. The resulting imaging protocol is finally used for image generation and reconstruction purposes. The pilot imaging at a low dose of radiation generated in the first step can be used in the reconstruction of the final image. It is advantageous in the method that the image parameters and the dose can be optimized for this purpose both in the projection plane and perpendicularly since a three-dimensional model is used. In this way, it is possible to take sufficient account for example of structures which require a dose reduction (for example the eyes in the case of head scans).

CLAIMS:

1. A method of adapting the imaging parameters of a medical radiograph of a body volume, comprising the steps:

a) obtaining a model of the body volume;

b) determining a region of interest (12) on the basis of the model;

c) determining optimal imaging parameters for the region of interest (12);

d) generating an X-ray image of the region of interest (12) of the body volume based on the optimal imaging parameters.

2. A method as claimed in claim 1, characterized in that the imaging parameters include the applied dose of radiation, the voltage of the X-ray tube, the current of the X-ray tube, the aperture setting, the filter setting, the imaging duration and/or the imaging area.

3. A method as claimed in claim 1, characterized in that the model of the body volume is obtained from a preferably three-dimensional pilot radiograph with a low dose of radiation.

4. A method as claimed in claim 3, characterized in that the pilot radiograph is used in the generation of the X-ray image in step d).

5. A method as claimed in claim 1, characterized in that the model of the body volume is obtained from stored previous radiographs of the body volume or from a stored patient model.

6. A method as claimed in claim 5, characterized in that the model of the body volume is adapted to at least one current radiograph.

7. A method as claimed in claim 1, characterized in that the X-ray image in step d) is reconstructed from projection images from various directions, and in that a minimum

aperture opening of the X-ray apparatus is defined such that the region of interest (12) is detected along with a predefined border area in all projection images.

8. A method as claimed in claim 1, characterized in that the X-ray image is reconstructed from projection images from various directions, and in that the current of the X-ray tube is modulated as a function of the projection direction such that an image quality measure relating to the region of interest (12) is observed.

9. A method as claimed in claim 1, characterized in that maximum doses of X-ray radiation that must be observed are taken into account when determining optimal imaging parameters in step c).

10. A control device for an X-ray apparatus for generating X-ray images of a body volume, comprising

- a model unit (20) for obtaining a model of the body volume;

- a definition unit (21) for determining a region of interest (12) on the basis of a model provided by the model unit (20);

- a parameter determination unit (22) for determining optimal imaging parameters for the region of interest (12) determined by the definition unit (21).

11. A control device as claimed in claim 10, characterized by a user interface (3) which in particular permits interaction with the definition unit (21).

12. A control device as claimed in claim 10, characterized by an interface for the connection of an X-ray radiation source and/or of an X-ray detector.

13. A control device as claimed in claim 10, characterized by an image processing unit (23) coupled to the model unit (20), for processing X-ray data to form an X-ray image.

14. A control device as claimed in claim 10, characterized in that the imaging parameters include the applied dose of radiation, the voltage of the X-ray tube, the current of the X-ray tube, the aperture setting, the filter setting, the imaging duration and/or the imaging area.

15. A control device as claimed in claim 10, characterized in that the model unit (20) is designed to obtain the model of the body volume from a preferably three-dimensional pilot radiograph with a low dose of radiation.

16. An X-ray apparatus for generating X-ray images, comprising

- an X-ray radiation source;
- an X-ray detector;
- a data processing unit connected to the X-ray radiation source and the X-ray detector, for controlling the image generation and for processing the radiographs obtained;

wherein the data processing unit is designed to carry out the following steps:

- obtaining a model of the body volume;
- determining a region of interest (12) on the basis of the model;
- determining optimal imaging parameters for the region of interest (12);
- generating an X-ray image of the region of interest (12) of the body volume based on the optimal imaging parameters.

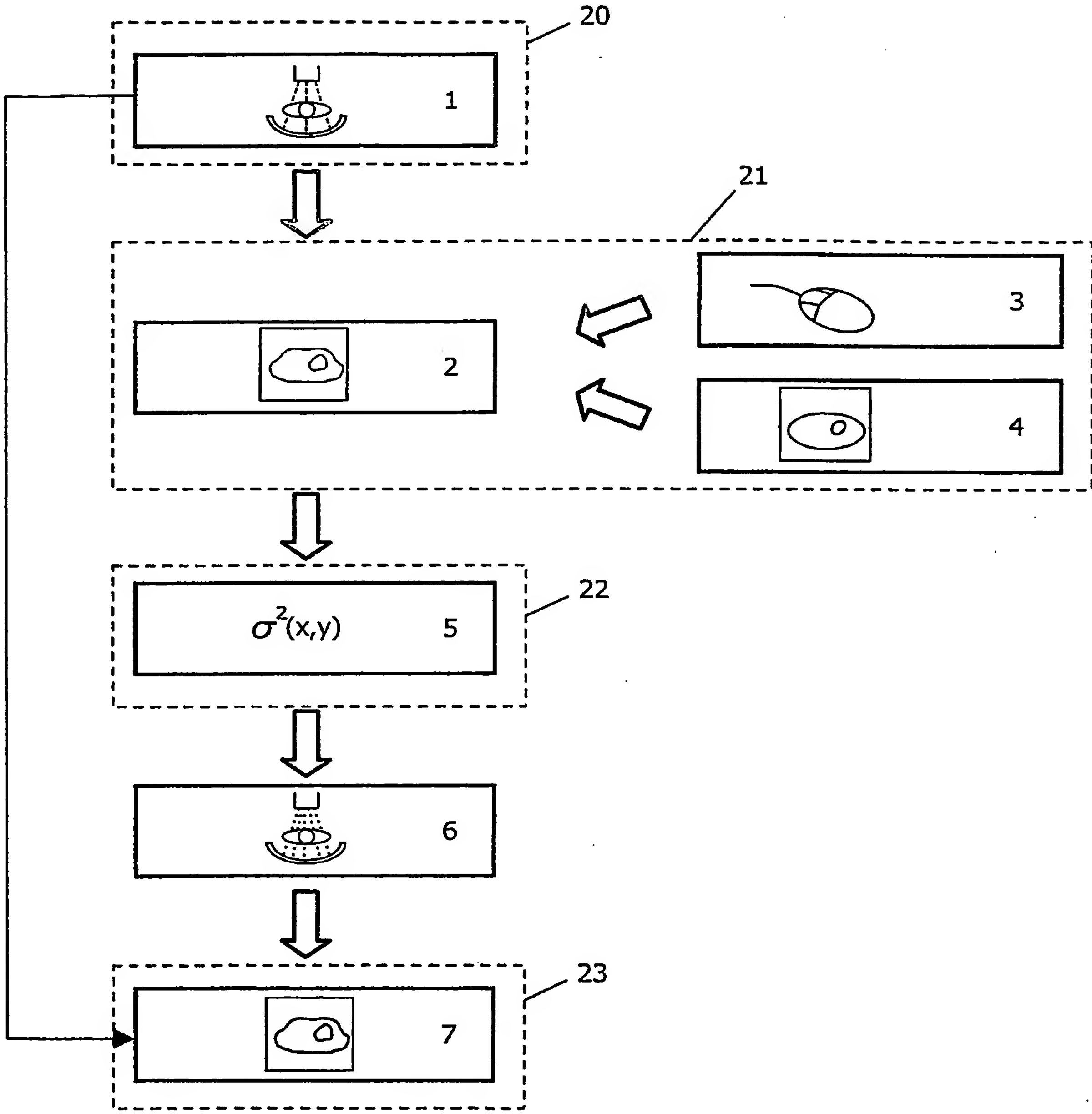


FIG.1

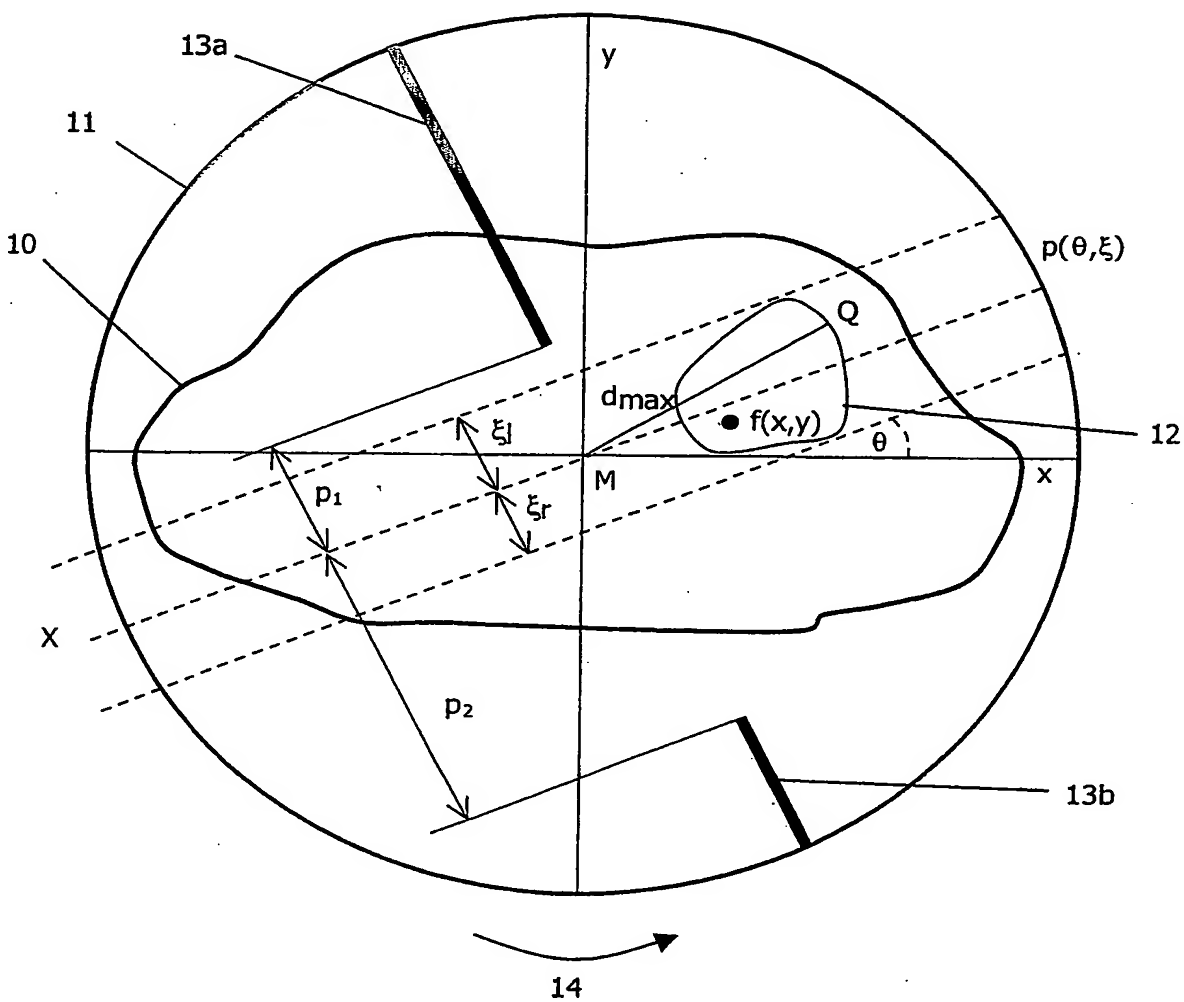


FIG.2

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 September 2004 (23.09.2004)

PCT

(10) International Publication Number
WO 2004/080309 A3

(51) International Patent Classification[7]: A61B 6/03

(21) International Application Number: PCT/IB2004/000527

(22) International Filing Date: 27 February 2004 (27.02.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
03100589.5 10 March 2003 (10.03.2003) EP

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM,

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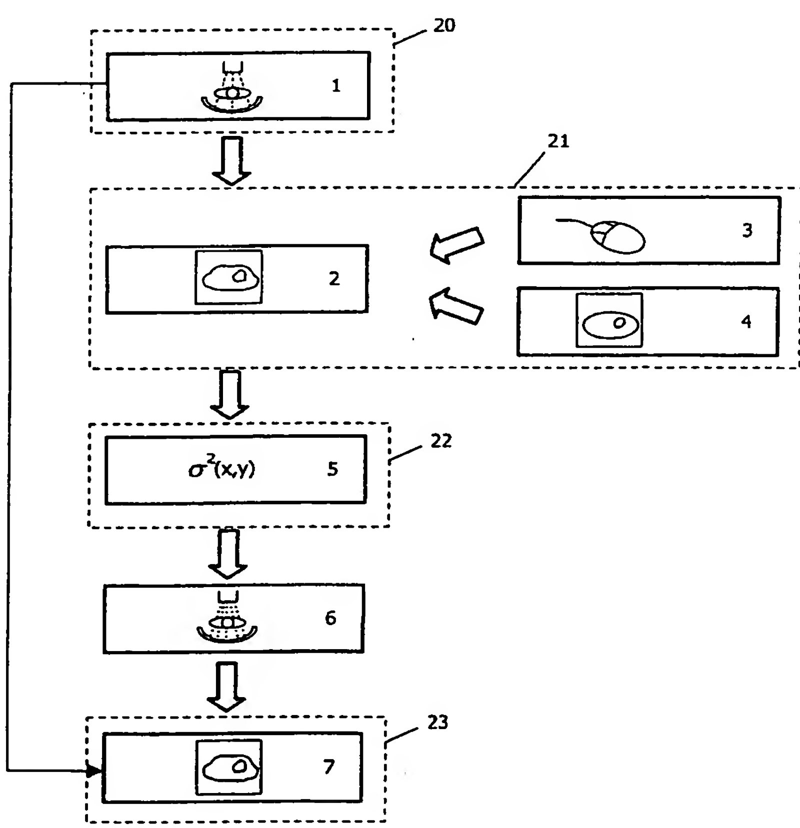
(54) Title: DEVICE AND METHOD FOR ADAPTING THE RECORDING PARAMETERS OF A RADIOGRAPH



(57) Abstract: The invention relates to a method of adapting imaging parameters for a computer tomographic radiograph of a body volume, comprising the following steps: obtaining a three-dimensional pilot radiograph with a low dose of radiation (1); determining a region of interest and a desired image quality in the pilot radiograph (2) with the aid of a patient model (4) or interactively (3); determining optimal imaging parameters (5); generating an X-ray image using the determined imaging parameters (6). Optionally, the X-ray image is combined (7) with the pilot radiograph.

WO 2004/080309 A3

TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) **Date of publication of the international search report:** 16 December 2004

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2004/000527

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B6/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 195 409 B1 (CHANG LINDA ET AL) 27 February 2001 (2001-02-27) cited in the application abstract; figures 2,3 column 1, lines 10-14 column 2, lines 6-52 column 2, line 66 - column 3, line 63	1,2,10, 14,16
X	US 6 377 656 B1 (UEKI HIRONORI ET AL) 23 April 2002 (2002-04-23) abstract; figures 1,2 column 2, lines 22-45 column 9, line 40 - column 10, line 59 column 13, lines 48-53 column 16, line 43 - column 7, line 8 column 17, lines 46-63	1,2,10, 14,16

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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23 June 2004	05. 10. 2004

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2004/000527

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/035511 A1 (REITER HARALD ET AL) 20 February 2003 (2003-02-20) abstract; figure 1 paragraphs ‘0004! - ‘0007!, ‘0015!, ‘0017!, ‘0027!, ‘0028!, ‘0037!; claims 1,6	1,2,10, 14,16
A	US 6 507 639 B1 (POPESCU STEFAN) 14 January 2003 (2003-01-14) abstract; figures 1,3 column 2, line 65 - column 3, line 29 column 6, lines 12-49	1,2,9, 10,14,16

INTERNATIONAL SEARCH REPORT	International application No. PCT/IB2004/000527

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-2, 9, 10, 14, 16

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-2, 9, 10, 14, 16

   Method, control device and X-ray apparatus for adapting the imaging parameters of a radiograph.
   A contribution to the prior art might reside in the choice and combination of the imaging parameters to be optimized.

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2. claims: 3-6, 15

   Method and control device for adapting the imaging parameters of a radiograph.
   A contribution to the prior art might reside in the features of the model of the body volume (claims 5, 6).

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3. claims: 7-8

   Method for adapting the imaging parameters of a radiograph.
   A contribution to the prior art seems to reside in the definition or modulation of a scanning parameter (i e. aperture opening or X-ray tube current) during acquisition of projection images from various directions.

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4. claims: 11, 12, 13

   A control device for generating X-ray images of a body volume.
   A contribution to the prior art might reside in the features of a user interface permitting interaction with a definition unit for determining a region of interest (claim 11).

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte[redacted]tional Application No
PCT/IB2004/000527

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6195409	B1	27-02-2001	NONE			
US 6377656	B1	23-04-2002	JP	10308899	A	17-11-1998
			CN	1255279	T	31-05-2000
			WO	9852388	A1	19-11-1998
US 2003035511	A1	20-02-2003	DE	10132816	A1	05-12-2002
			EP	1262147	A2	04-12-2002
			JP	2003047606	A	18-02-2003
US 6507639	B1	14-01-2003	WO	03022018	A1	13-03-2003
			EP	1421831	A1	26-05-2004